

STANFORD RESEARCH INSTITUTE

To: ARPA Computer Network File (7013)

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From: H. B. Shapiro

Location:

Subject: A Look At The Problem of Host to Host  
Communication

Answering:

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I Ground Zero

It is expected that 9 to 12 months from now, IMPs and communication facilities will be delivered and installed at the three sites of the initial network. The hosts of the initial network should then be ready to participate in network tests and then in actual network operation. For such participation to occur, host software and hardware items will need to be developed or modified; also some special IMP programs will likely need to be rewritten to accommodate the host.

Work is now underway to define the nature and magnitude of the tasks ahead. Several reasons make it necessary to start this work now. First, estimates are needed of the resources required on the part of ARPA and its contractors of elapsed time, man power, and money in order to get the hosts in order. Also solid background and experience with host problems must be developed by ARPA and its contractors so as to provide early interaction with the network design, especially in evaluating the development of the IMP and the network protocols.

Finally, time is needed to convey the knowledge gained to those ARPA contractors joining the network at a slightly later time.

II Major Areas of Activity

A. General

Three major problem areas must be tackled. First, effort must be devoted to the development of mechanisms whereby executive programs of different hosts can communicate. Also effort must be directed to the development of mechanisms for effecting communication between user programs.

Finally, facilities need to be developed to perform tests upon the initial network and to assist in the identification of faulty hardware or program elements.

The result of such efforts should affect several aspects of the IMP and network system design. These aspects include: traffic statistics, the role of the "host" side program in the IMP, the acknowledgement procedures, the IMP message disassembly and assembly process, and fault recovery processes.

#### D. Communication Between Executive Programs

It is necessary to examine the nature of the flow of control information between host computers. Such information is concerned with the high level coordination of the host to host process, as opposed to the processes carried out by the user oriented programs. These higher level processes might deal with: 1) the movement of files, 2) the control of remotely located program, 3) the screening of attempted uses of the network, 4) the execution of login and logout procedures, if they are used, 5) controlling the access and other uses of a host's resources by the network, 6) validation of identifications, and 7) execution of procedures for coping with network faults.

To permit communication between executive programs, some form of protocol should be established encompassing message formats, acknowledgement procedures, codes, and object names. It is not clear at the moment whether a common network protocol need be used, or whether many such protocols will exist, say one per host pair.

#### C. Communication Between User Programs

A major problem at the user program level arises from the large variety of terminal devices that might need to be served by any given user program. Thus there are teletypewriter devices using hardcopy, CRTs using storage tubes, CRTs using continuous refreshing, light pens, tablets, mice, and contact closures. In many instances the user is provided at the terminal with some form of very rapid feedback in response to an action generated by him. The possible sources of these feedback signals must be examined.

Typically the user creates a command by serially transferring the elements (e.g. characters) of the command to his system. Recognition of the end of a command input may be provided by the system through an analysis of the growing input character string. The location of the recognition process, local or remote, can significantly affect the nature of the messages exchanged between hosts.

Looking at the information to be processed there are matters of accommodating a large variety of file formats and data codes as used by the many hosts of the network.

#### D. Network Testing

Two goals can be identified pertaining to network testing. First, the tests should demonstrate the operational characteristics of the network in a "true" environment. These tests should exercise all the network functions and measure the various network response times. The other objective is to aid in the identification of faulty elements during the period of initial debugging. The network elements of concern here are: 1) at the host-hardware (e.g., at the interface with the IMP), and programs (e.g., the monitor, the communication executive), 2) at the IMP-hardware, programs (contractor supplied and host supplied), and with the communication facilities-modems, transmission circuits, and switches.

The approaches used to effect the testing should be such as to minimize the time required of the host computer and to minimize the effort required of the ARPA contractor personnel (e.g., programmers, engineers). These constraints make it desirable much testing to proceed using only the IMPs and the communication facilities. The remainder of the tests should be efficient in their use of any of the host's facilities.



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By April 1 the tasks set for the Working Group should be essentially completed, in particular, the IMP should have been defined. I believe the Working Group should continue to function beyond April 1, and be expanded to include a representative of the University of California at Berkeley (UCB). The major objective of the Group, would be to solve those problems required to make their host computers working elements of the ARPA network by about January 1969. At that time their IMPs should have been delivered, installed and debugged. The organizations represented by the Group, excepting RAND, are responsible for the first hosts to join the network.

This activity of the Group should have a significant impact upon the other users of the network, and upon the contractor responsible for the IMPs. For one thing, the Group would be identifying and solving problems that the other users will encounter later. The work of the Group should be fully documented and available to these other users to use or ignore, as they see fit. Also, the Group could provide, through ARPA, an interaction with the IMP development: providing answers to problems raised by the contractor, indicating the need for modifications to the initial IMP design, and evaluating the IMP as it progresses.

The Group might well devote the four month period, April through July 1968, to an examination of their mutual problems, studying alternative solutions, and finally selecting the solutions they wish to implement. Every consideration would be given to selecting those solutions that would fit into the entire network. Consultations with other network users would be vigorously pursued by the entire Group during that period.

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In the succeeding five months, August through December 1968, each site would undertake to implement their chosen solutions, involving the writing and debugging of host programs, of specialized IMP programs, and the installation and debugging of interface hardware for the host. The members would appraise the group of new problems encountered, and approaches taken.

At the outset each Group member would review, for all the other members, the important features of his host computer's software, hardware, operating system, and general rules of procedure. An initial inventory list would be constructed by each member of those resources of his host system that could be used by others of the network. Such a list, always subject to revision by the member, would account for the programs, storage media and volume, peripheral devices, etc. The inventory doubtless will be less than the total resources of the member's host system.

Broad gauge policies would be mutually developed, among all the members of the group, regarding the rules of usage, and protocols between monitors, supervisors, operating systems, or whatever. A suggested set of topics for study includes:

- (1) The control of resources
  - a) Control of access to a resource
  - b) For those entitled to use a resource, the allocations (e.g. space and time) to be used
  - c) User verification mechanisms
- (2) The elements of information to be exchanged between host operating systems
- (3) Mechanisms for naming system elements
  - a) Users
  - b) Files
  - c) Programs
  - d) Miscellaneous items
  - e) Reserved names
- (4) Acknowledgements between hosts for closed loop operations

(5) Exception and fault conditions

- a) Crashes
- b) Recoveries
- c) Self-protection

(6) Message protocols, formats, and codes

An intermediate goal for all would be the development of host programs for use in the testing of the initial network, primarily the performance of the IMPs. These host programs might be required to generate, receive, and analyze messages, thus providing traffic sources and sinks.

Very truly yours,

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